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IX.

WESTERN EXPLORATION.

BY LIEUT. GEO. M. WHEELER, U. S. ENGINEER CORPS.

A large gathering of the Fellows was present at Association Hall on the evening of December 23d, to listen to an address on Western Exploration, by Lieutenant George M. Wheeler, U. S. Engineer Corps, who, upon being introduced by Chief-Judge DALY, said:

MR. PRESIDENT, FELLOWS OF THE GEOGRAPHICAL SOCIETY, LADIES AND GENTLEMEN: — It affords me great pleasure to appear before you, in response to a call from your committee, for the purpose of narrating features connected with the expedition that has been intrusted to my charge, during the few past years, and I hope to be able to speak succinctly of a few of the great number of important questions entering into the subject of geographical inquiry, now being carried on in the immense territory of the United States west of the Mississippi river.

I have no need to tell a critical assemblage like this, that for the first time I am placed upon the stage to attempt to instructively entertain an appreciative audience. I cannot expect, and hope that you do not, that I shall meet the requirements of the trained and eloquent speaker; but if you will bear patiently with me, I shall attempt to portray, in addition to some scenes and incidents, and professional results of one of our field seasons, a brief resumé of what has been done in this comprehensive field heretofore, and in addition thereto, treat of a few of the prominent and pertinent points of the relations that interior surveys bear toward the government.

CONDENSED HISTORICAL RESUMÉ OF EARLY EXPLORATION.

As is well known by most of those present, shortly after the commencement of the present century, and but a little subsequent to the

establishment of our independence, the United States having acquired what was known as the "Louisiana purchase," President Jefferson, then chief magistrate, was the first to conceive of the necessity of sending to this portion of the continent organized parties to examine into the purchase, and to find out what the government had secured. At this time the expedition headed by Lewis and Clarke was organized, the former a nephew of, and military secretary to, the President; the latter an officer in the army. The inception of this work has not merely signalized the wonderful intuitive power that has been accredited to Jefferson, but shows at this early day the value attached to systematic governmental support.

With all the facilities at this time available, this, one of the most prominent expeditions of the first quarter of the nineteenth century, started out to pierce the north-western interior. This was the first well-authenticated and well-equipped expedition that had for its mission an inquiry into the extent and resources, then comparatively unknown, of this great and almost continental area. It is true that at an earlier period, in our south-western territory, the trips of the early Jesuit missionaries, following the expedition for the conquest under Cortes, and later parties, sent out under the sanction of the government of New Spain, both inland and coast-wise, had their origin and results much in advance of the historial epochs of the colonial, State and territorial independencies of the government of the United States. But their results were comparatively of little avail in bringing to light facts and deductions susceptible of being drawn from these great areas.

Dwelling with so much significance upon this individual effort in the threading of interior spaces has not been done with a view to pass encomium upon one more than any other expedition, upon one more than any other individual, but to draw your attention to an epoch in history which it has been my pleasure to see so distinctively noted within the last few years. Later, Lieut. Pike, afterward Gen. Pike, killed in the war of 1812-14, headed an expedition extending over a period of three years, first in and about the head waters of the Mississippi, and afterward to our south-western boundary, then limited by the Arkansas, and, from a misapprehension of geographical boundaries, having passed beyond the limit of what was then the possessions of this country, found himself and party upon the western borders of the Rio Grande. Stockading himself against the Indians, he found but too soon that another people were more his enemies, and here he was taken prisoner by the Mexican authorities in 1807.

It has been our good fortune during the past season to ascertain

the fact that at the junction of the San Antonio and Conejos creeks, in the south-western part of Colorado, remains the remnants of a stockade, marking the spot where this occurred. Other evidence was accumulated, showing that his parties crossed the Sangre de Cristo pass. All the results of that important expedition never reached the archives of the government, and to-day they lie in the records of old Mexico, or with the priests of the inland territory.

After the war of 1812-14, the country having reached a stage of comparative quiet, explorations again resumed a magnitude not known before. In the years 1819-20, after the organization of the Corps of Topographical Engineers, whose labors in this field are well known, Major Long started in 1819 from the Alleghanies. The results of this expedition, in view of the improved instruments and methods, and the facilities that could be placed at his command, were much in advance of what had been accomplished before, and the maps of routes then made were of great importance to the government, and frequently consulted.

But little was done after this expedition until the time of Bonneville, in 1832-36, who, following out the endeavor to explore lines leading into the then inaccessible portions of the interior, was absent so long from his command as to be dropped from the rolls of the army. However, his journal, notes, plates, etc., when received and compiled, added largely to the stock of geographical knowledge relating to this portion of the public domain.

Again, an interval, and we find in 1842 that the then Lieut. Fremont, of the Corps of Topographical Engineers, having been assigned by President Tyler to command one of the most important expeditions into the interior of the country west of the Missouri river, started from St. Louis,—another instance where a President of the United States was impressed with the grave importance of a correct knowledge of our immense western possessions, that embrace some of the most important areas of drainage in the world. The parties of this expedition were engaged in field and office operations until the close of the season of 1845.

The importance attached to the results obtained, and their effect when utilized, upon the line of march of emigration toward the West, has become a matter of history more fixed in the minds of those who have traversed the regions beyond the Alleghanies.

In speaking of the West, it is well to draw attention to the fact that the Mississippi and Missouri rivers marked the geographical limit of the great West at this period, a line of easy transit, strangely enough, acting as a barrier to civilization; still beyond it little

authentic was known. How well has been proven since that time that one of the powers that rule the world (hard money) has attracted multitudes to the shores and slopes of the Pacific! After the discovery of gold in California, there was established a steamship line between New York and San Francisco; subsequently a telegraph line, and later still the Pacific railroad became an acknowledged fact — each forced to completion from the necessities of the government and the demands of inter-commerce. However, since the early days of exploration and survey, the boundaries of our western domain have passed through successive changes.

For a correct understanding of these changes I would refer you to one of the maps of the Statistical Atlas of the United States, recently compiled under the direction of Prof. F. A. Walker, of the Census Bureau, that relates to the acquisition of territory in the United States, and its subsequent distribution into political divisions.

This expedition (Fremont's) was followed by others, all of more or less importance, and especially so since by them was proven the necessity for the organization of parties to obtain information for the government in this vast inland interior. To carry out such a policy, from the year 1846-47 until 1852, expeditions for the Pacific railroad surveys and others were sent out, mostly under the auspices of the War Department. Many of the names of the heads of these expeditions are familiar to you all.

The former were sent out at the instance of the Secretary of War, to investigate routes of travel to the Pacific, a subject exciting public attention at that time. With matured plans, methods of observation and investigation, with a *personnel* selected by the departments and bureaus, several well-organized expeditions took the field, and every one knows more or less of the results of the Pacific railroad surveys. Stores of useful knowledge accumulate so rapidly in this country, and still there remains so much to be learned, that it almost seems amiss to ask one to look backward; indeed, it may appear that I, of all others, now directing a work that has its future nearly all before it, can hardly be pardoned for asking a few moments of retrospection. Perhaps it may be unfortunate that we should stop for a moment to look backward, but in the operation of geographical inquiry and endeavor, like all others, we should look upon both sides of the question; and one of the lessons that may be drawn is, that it has been principally "measures, and not men," that have governed the intervals during which expeditions have been dispatched into the unsettled and inaccessible portions of the far West. It seems proper to add that the results of the Pacific railroad surveys led to the construction

and compilation of what were then the most accurate maps. Warren's memoir, which forms a part of the Pacific railroad reports, fully sets forth an historical resumé of this matter, and has been frequently consulted, and is the authority up to the spring of 1857. Although the topographical material had not been gathered for the precise purpose of making maps, yet I know that every one present will admit its pertinence when I say that the government and the public may well feel thankful to the wisdom of the minds that conceived the propriety of placing all this material in the form of a map, whose uses have since entered into the education of the country. Subsequent to the close of the Pacific railroad surveys, and the resulting maps and reports thereon, officers of the then Corps of Topographical Engineers prosecuted further surveys in this region, called for by the necessities for information experienced by the War Department, bearing upon communication and supply between interior remote points. Their number was comparatively few, owing to the commencement of what has since grown into a system of river and harbor improvements, whereon officers of this corps were preferably placed. While many important expeditions were in progress, boundary surveys between the United States and Great Britain on the one side, and Mexico on the other, were carried on. The names of Graham, Emory and Parke are familiar in this connection.

Notable among the later expeditions are the expedition of Warren to the Black Hills in the North-west in 1855-'57; Macomb in 1859, outward from Santa Fé to the junction of the Grand and Green rivers, and return; Simpson, with the army under Johnson, in Utah, to the eastern base of the Sierras, at Carson city, thereby shortening the principal wagon route to the Pacific, and perhaps others which, in the hasty mention, may have escaped attention. Their names and facts have been placed upon the record, and have already passed into history.

I may be excused for calling attention to a portion of the President's message sent forward to Congress during the past session relative to surveys, wherein the Chief of Engineers states in referring to the resumption of labors upon interior topographical surveys by Major Long, the following appears: "And succeeding him, these were continued by officers of the army, whose names would furnish a long list of men distinguished in their profession." I recollect most vividly a statement made not long since by a prominent Senator from the West, while speaking of no less a personage than the late Senator Fessenden from Maine, that this distinguished statesman, although conversant with legislation in its broadest sense, thoroughly informed

as to governmental necessities, well versed in the manners, customs and wants of the people, still never seemed to comprehend that the United States had expanded beyond the Alleghanies, while at and beyond the extremities of arteries leading to the heart of this portion of the continent more than elsewhere the government should extend its powerful protection.

Subsequent to the war there have, also, been organized and carried out under the Engineer Department of the army, the Geological Survey of the 40th Parallel, in charge of Clarence King, from the Department of the Interior, the United States Geological Survey of the Territories under Prof. Hayden; the survey of the Valley of the Colorado under the Smithsonian Institution, in charge of Mr. Powell, the latter was transferred at the past session of Congress to the Interior Department, also the expedition for the demarkation of the northern boundary under the State Department, with Archibald Campbell as Commissioner and Major Twining, Corps of Engineers, as chief astronomer; and at the head-quarters of the several Geographical military divisions and departments officers of the Corps of Engineers have been engaged in reconnaissances and surveys of various kinds, but of their several characters and objects, I feel that it is not my mission to speak. Their works are passing into history, and your distinguished President, Chief-Justice DALY, in his annual address, chronicles their current operations.

DESCRIPTION OF EXPEDITION OF 1874.

The system of opening a means of communication between points widely separated in the interior had become well advanced at the beginning of the rebellion, and it was found both judicious and economical to make expenditures of the public money for interior surveys, and certain improvements and constructions growing out of the same for the uses of the War Department, and in furtherance of industrial interests. And as has before been stated, officers of the corps of Topographical Engineers were called upon to take a prominent part in this task. This corps during the interval of the war were merged with the corps of Engineers proper, and their duties assimilated thereunto. What might have grown from this want on the part of the government had not the war of the rebellion been prosecuted, let none of us imagine. Inasmuch as it has been a part of my task to look a little into what has been done as well as to project current and future operations, I may be pardoned for thinking to maintain that what has been partially begun, and in a small degree carried out

by myself and others of late years, might easily have become a thing of the past, but for the intervention of the war.

However, finding myself in the year 1869, a member of the staff of Brevet Major-General E. O. C. Ord, then commanding the Department of California, and under his direction being sent to investigate certain practical subjects relating to interior communication, for the first time in my experience as a public officer, it became my duty as it was my pleasure to examine topographically portions of the areas shown upon the progress map thrown upon the screen. After returning from that trip, which was carried on at a small expense, and which attained nothing beyond the dignity of a reconnaissance, there grew into tangible form evidence favorable to a continuance of Explorations and Surveys which it was then deemed proper to lay before the War Department. The trip of that year had its close, and its results were immediately made available, but it was not until the spring of 1871 that the War Department, by authority of appropriations made at that session of Congress, saw fit to send out in force an expedition complete enough to take cognizance of the binding together, as it were, of the old routes of survey and compacting them into a whole, giving an order and form based upon the physical details of *areas* as contradistinguished to *lines* that singularly enough had never been attempted before.

Returning from the field at the close of the expedition of 1871, the project of interior survey that I have hastily brought to your notice while explaining the "Progress Chart," was laid before General Humphreys, Chief of Engineers, and General Belknap, Secretary of War, and approved by both. Their hearty support has been since maintained, for a lack of which and the intelligent aid of a few far-seeing friends in Congress, the expedition of 1874 would not have been sent out for the further prosecution of these labors. The expeditions of 1871, as well as those of 1872-'73, took the field and returned, harmonizing their field and office results as far as could be, so that the mass of useful information might become immediately available to the War Department, thence to the other departments of the government, and indirectly to the public. And it is with no little pride that I quote the following paragraph from the annual report of the Chief of Engineers, submitted to the Secretary of War, and forwarded to Congress at its present session:

"By experience and improvements in methods and instruments, the value of the results is annually enhanced and the cost of the work amply repaid."

But these matters interest but very few of you, and therefore I

shall at once come to a description of our trip during the past season, which has been directed to portions of the political divisions of Utah, Nebraska, Colorado, New Mexico, and Arizona. The number of parties in the field have been 9, the number of officers and assistants 86, fewer than the usual number, since our routes lay in regions not infested by hostile Indians, and hence no escorts were required. These have been distributed into the several geographical fields of inquiry, including the cognate branches of scientific research, geology, paleontology, mineralogy, natural history, etc. The force consisted of officers of the different arms of the service, aided too by professional gentlemen drawn from civil life, since this, like all classes of interior works carried on by the War Department, have been partly military, partly civil, working always in harmony, as it has not been deemed essential to confine labors in so comprehensive a field to one class of persons.

The point of departure was Pueblo, Colorado, at the end of the little narrow gauge railroad that follows the eastern base of the Rocky mountains, south from Denver, and to which point persons, animals and supplies could be easily forwarded. The detailed operations of the Survey, however, were to be to the southward of the Spanish peaks, marked points noted by all early explorers, travelers and settlers throughout the region, and lying for the greater part in New Mexico, while the basins of drainage entered and occupied were the Arkansas, Cimarron, Mora, Pecos, Rio Grande (its eastern, upper and western branches), and the San Juan rivers, all possessing a topographical grandeur each its own, yet each different in its local physical peculiarities, each as large as one of our minimum states, with all due respect to Rhode Island and Delaware; the entire area being fully 35,000 square miles, so large that we might almost (to speak figuratively) pick up the whole State of New York, drop it into the same, with a prospect of total immersion. The points of prime geographical necessity were those from which a series of base lines were measured from points, astronomically determined with the utmost accuracy, and located in vicinity of Hughes, Colorado Springs, Labran and Trinidad, Colorado; Cimarron, Fort Union, Las Vegas, and Santa Fc, New Mexico, at which points bases, measured and developed to check the main triangulation extending throughout the mountain ranges, were laid out. Three parties were engaged in the establishment of interior astronomical points and the prosecution of the main triangulation, and others in filling in from main topographical stations by other trigonometrical means and collecting the topographical details necessary for the obtainance of all the horizontal

and vertical lines requisite for the map. It may be well here to explain that in this survey for mapping considerations alone, the engineer is compelled to apply three of the most prominent of the scientific branches in order to obtain satisfactory results; *i. e.*, Astronomy, Geodesy and Topography, which go hand in hand, immediately allied with the hypsometrical determination of altitudes. This has been done with a degree of success not marked in the earlier stages of the work, but most gratifying to all who maintain an interest in it. Persons specially skilled in the forms of the present and extinct fauna and flora of this region have been afforded facilities to prosecute their studies in connection with the movement of the field parties with marked success. As, however, this work, founded upon the necessities of a department of the government alone, can entertain but one standard, practically that of paying its way as it goes, the latter may not have been brought to so full a standard of excellence, as in parties which the government has at times sent out to prosecute especially this class of examinations, yet in the humble way in which these matters have been brought to fruitful results, it is believed that for the limited time and means much has been added to the store of knowledge in these important branches of science, and to the individuals who have been responsible for, and who have accomplished this work, most of the thanks are due.

I will ask you to follow me while I describe rapidly the march of that part of one of the nine parties conducted by myself out from Pueblo to Pagosa Springs, in the valley of San Juan, and thence returning to the valley of the Arkansas. As no statement of mine will accommodate your minds to the peculiar atmosphere and structure of mountain and other forms that meet the traveler in these regions, I will confine myself to the simple line upon the map, and ask you to trace with me the locus and windings of this route.

The road from Pueblo to Fort Garland, on the eastern side of the Greenhorn range, that faces outward toward the Arkansas valley, skirts the foot-hills of this magnificent series of ridges, that has lately attained a more practical grandeur on account of important mining interests that are being developed, notably in the Rosita silver district. New discoveries are also being made, and when one can look at a mountain range and imagine that *silver* may come from that enormous structure, silver already found, or silver yet to be found, there grows an idea of enchantment that makes the traveler, the practical man, or the mining operator stoop with awe upon beholding so colossal a treasure house in which is seen the basis of future economic wealth now lying hidden, and awaiting only the call of ener-

getic labor to withdraw it for the uses of mankind. We started from Pueblo and traversed the base of this range during the month of August in the most delightful part of the season, and crossed the Sangre de Cristo pass (a fearful name, but the pass fully justifies it), until we entered the valley of the Rio Grande and the famous San Luis park, so called, an immense detrital plain simply, park it is not, valley it might be called from its physical shape.

Reaching the little post of Fort Garland lying upon a strip of land between Sangre de Cristo and Ute creeks, we came to the border line, of government civilization at least, for here we find the same located in a few adobe houses in which government property is stored half in corral and half in dingy flat top huts, with apertures resembling loop-holes, although fashioned by nature. Here were stationed a fraction of the army so well sustained upon our frontier for the protection of civilization advancing in face of many obstacles.

Here we rested for a few days in camp on a little island beautifully ensconced among the trees. An island because it was like an oasis, situated on a dusty plateau, surrounded by a little stream of about two feet of water, all from the Ute creek, or what is left of that stream after emerging from the foot hills. From this point directly across the wide valley of the Rio Grande, we reached a number of Mexican settlements on the western side of the most southerly county of Colorado; thence farther westward to the little settlement of Conejos. Without guides and without escorts, we passed from this point up the stream of the same name, changing soon our route to the northward, and climbing a noticeable peak that from the valley below stood out boldly in the horizon, the view from which can only be compared to that of entering a paradise.

One of the earliest points visited by us was named Prospect peak, from which, looking eastward and north, is seen the great San Luis plain, and to the west the little valleys of the Conejos and its minor tributaries clothed with grass, presenting most beautiful oscillations of color to the eye, while farther in the horizon lay long mesa lines heavily clothed with pines and deciduous foliage, all lending a calm repose to the landscape seldom witnessed.

Within these tributaries we spent a portion of the season; finally, after treading in and out, reached the sources of the eastern streams, and one stands upon the backbone of the continent, at a mountain summit rising majestically from the half plateau, half mesa forms, standing a proud and conspicuous monument (duplicated nowhere, so far as I know), marking the powerful line of serrated ridges, which

from the 49th to the 32d parallel, divide the waters of the Pacific from those of the Atlantic.

Here we encountered storms, with thunder and lightning, which, after their exhibition of temper, left a clear and radiant sky, lighting with magnificence the well-developed flora of this region. Continuing westward, we followed with considerable difficulty a stream, which afterward proved to be what will be named the eastern branch of the San Juan, to its junction with the main or upper fork, thence to the famous hot springs at Pagosa. These were examined by parties under Col. Macomb, in 1858, who visited them while exploring for a wagon road, and have been described by Professor Newberry, geologist to that expedition, in a report that it is believed has never been published. This was a point for rest and rendezvous, and the most westerly reached by myself. In a trip to Sierra Amarilla, in the valley of the Chama, the backbone of the country was again crossed, but, how different the grandeur of this latter crossing. Here the erosion of the horizontal strata leaves a poorly marked line from which waters flow either to the Atlantic or Pacific. Indeed, it is most difficult to determine the precise points of this line from which precipitate moisture would flow to hither or yon side.

Returning from Pagosa, with a specially organized party, the main head of the San Juan was reached, thence through flood, mud, snow and forest we reached the westerly arm of the Rio Grande, which nestles its perennial head within the southern line of the Uncompahgre mountains, grazing most marvelously the heads of the San Juan, about which occur a series of complicated folds for a distance of 80 miles. Thence flowing to the south, it comes to an area covered with quaternary deposits in this portion of the Rio Grande basin. One little experience gathered while making this trip, although not altogether agreeable, may perhaps amuse, if not interest you all: While camping near the summit of one of the many ridges skirting the tributaries of the upper San Juan, at an altitude of 10,250 feet, a heavy rain began just at dusk, and minus an epicurean's supper, with a wet bed, without forage for the mules, with numb fingers, and dread of the night, we were made the recipients suddenly of a succession of grand physical phenomena, which it has not been my fortune to witness before. Just at the small hours of the morning, while looking up through the mantling cover of fir and aspen, could be seen glimpses of wavy clouds and the moon clearly shining, while the peculiar shuddering effect that comes from cold water dripping down one's back was experienced by your observer, although carefully ensconced in his blankets, and while simultaneously in another quad-

rant of the heavens a snow storm of considerable vigor was actively going on.

Indeed we had snow about four inches deep, or rather in the morning we had this. During this interval the grumbling followed by vivid and clear flashes of lightning afforded yet another species of pyrotechnics on the part of the heavens, all creating an awe of the power of nature more impressive than all powers of description. One by one was heard the crack of trees, broken and demolished by the violence of the wind, driven at a fearful rate. You can well imagine how much this was enjoyed, how much we all slept; but, fortunately for the alacrity which we desired in our homeward march, we found ourselves early on the road next morning. It is a matter worthy of scientific note, this peculiar relation between clouds, moonshine, clear sky and thunder, hail, snow, etc., which I believe has hardly ever been observed before. Marching steadily on in this portion of our season's trip, we reach a point near the south fork of the Rio Grande, thence to its junction with the main stream, and to the little mining town of Del Norte, on the western side again of this great San Luis valley. Here another division of one of the small fractional part of the expedition took place—a portion withdrawing by stage communication leading to the Arkansas valley. In the latter direction your observer traveled hence to Pueblo. The season's trip was short, but one full of varied incidents, and of extended observation in the mountain portion of one out of the twelve extended trips taken by myself in the mountains of the west since the summer of 1868. While a fragment of the main party were returning under my direction, the remainder, under Lieut. Whipple of the army, prosecuted their inquiries westward toward the mouth of the San Juan, another, under Lieut. Marshall, were in the upper and northerly parts of the San Juan basin, among the mines lately discovered there, and succeeded in completing the triangulation begun in 1873, stretching well-conditioned belts of triangles southward, thus connecting with the series established in New Mexico in 1873. This party have accomplished their season's work, as have also the others, and returned to the office in Washington for the elaboration of results.

Lieut. Birnie directed a party immediately south of the main division, debouching from the mountains eastward at Cimarron, New Mexico, at the close of the season, having reached the western boundary of New Mexico, covering the area south to Abiqui in the valley of the Chama, and westward to include the main southern tributaries of the San Juan.

Lieut. Price, with a special triangulation party, to which were added a mineralogist and collector, occupied portions still farther to the south, their southward latitudinal line being that through Las Vegas, New Mexico, and their eastern limit the ridge of the main range bordering upon the plains, and dividing the valley of the Pecos from the Rio Grande.

Lieut. Blunt and party were assigned to a portion east of the main ridge, and bounded, latitudinally, north and south, by Las Vegas and Trinidad, Col., east by $104^{\circ} 7' 30''$ of longitude.

A special party for making collections in natural history and certain hypsometrical determinations followed a line leading from Santa Fé, via Fort Wingate, Camp Apache, New Camp Grant, Fort Bowie in Arizona, and returning via the same post, except Wingate, and including Forts Tularosa and Craig, to Santa Fé. Their labors were crowned with most gratifying results, at a minimum expense, and fill in gaps in the natural history areas, left vacant in other years, extending observations upon geographical distribution, with new forms.

Yet another party for special natural history and paleontological study, under Dr. Yarrow for the early part, and Prof. E. D. Cope for the latter part of the season, pursued their investigations in the valley of the Rio Grande, north of Santa Fé, and in portions of the southern San Juan basin, with most gratifying results. Prof. Cope has already submitted descriptions of new vertebrate forms that have been published.

A substantial stone and brick observatory was established at Ogden in 1873, and was occupied as a connecting station; to it were sent signals from the main stations occupied by another party in New Mexico, Colorado and Nebraska. In this connection I beg leave to state, that the Western Union and Atlantic and Pacific Telegraph companies have, as usual, extended most liberal aid to the longitudinal campaigns, without which efficient assistance, the same degree of success could not have been obtained. It may not be amiss to note, that in addition to the collection of topographical data, knowledge regarding the resources of the area traversed and surveyed, is one of the objects of investigation. As another and higher branch of the work, may be mentioned the establishment astronomically of geographical points at selected positions within the entire area, west of the 100th meridian. Many of these have been made available to the wants of the survey in carrying out its mapping objects. At others, conspicuous and solid monuments of stone, with the meridian line passing through them, have been erected, establishing a line

accurately marked available for the uses of governmental, corporate and private surveys, of practical advantage for all time to come, and the better understood the more known. Indeed, I have been informed, by the Surveyor-Generals of Nevada and of Wyoming Territories, that they had been made use of in the determination of the annual change in variation of the magnetic needle, a matter of great importance in fixing the location of the property of all settlers, thus acting as a safeguard against questions that may be raised in the future, as to the boundaries of landed properties, for in the newer portions of the great west, unlike New England, there are few artificial boundaries marking the extent of estates agricultural or mineral, and the variation of the needle entering as an element into all land titles, is subject to an unknown annual fluctuation. While to-day in portions of our western interior, land may not be worth the government minimum price, it may in the future be worth maximum sums. It is well then that these meridian lines are established at this early day, and future generations will be thankful for what has already been done, were the good work to be at once suspended.

While I can add but little of interest gathered by myself and individual members of the parties throughout the season, I will tell you that with but one casualty to be noticed, all have terminated their duties and reached the point of disbanding at Pueblo, and are now on their way, or have reached the office of the survey at Washington. To attempt at this time to lay before you any detailed features of the several branches of the work, as to their scientific or other values, would be exceedingly premature; I will leave that for another time. I hope that you will only expect of me statements made in the most general terms, for I have not deemed it advisable to come before you on this occasion with a finished scientific paper, nor with the dry material, such as often forms a part of many of the messages and documents to Congress, but hope that I will have proven to you that we are adding our mite in the line of geographical inquiry, and I beg to state that the time I can take from my strictly professional duties is extremely small. The region of country entered by the parties this year presents physical peculiarities of marked characteristics, consisting of massive mountain forms, plateaux and rivers; and although it cannot be said of a large portion of the area that the agriculturist has great attractions extended to him, yet with the advancement of legitimate mining enterprises there will grow up a demand for farming products that will not be dependent on cheap transportation, and will enrich, not as do the prairies, where sometimes corn has to be burned in the field, but with proceeds from a

ready and elastic market for all the productions of the soil. There are vast fields, suitable for grazing purposes, ready with their perennial and perpetual supply of nutritive grasses, sufficient for numerous herds of cattle and sheep, lying ready to provide beef for the nation—beef for the nation when the United States numbers her one hundred millions, as well as we have to-day beef for the nation with its forty millions.

This great supply, the capacity of which has been largely called into question during the past few years, attracts a growing attention, and to the question, Where is to come beef for the millions of Americans yet unborn? I would answer, after a personal observation of portions of 250,000 square miles of the western interior, "Go west" to the inland valleys, detrital plains and extensive plateaux, and there you will find provided, through the handiwork of Nature, material for the preparation of beef for these future millions, inexhaustible for several generations at least.

I wish to call your attention to the condition of some of the prospectors in South-west Colorado, as noticed during the past season. In the different trips in the western mountain region, especially east of the Sierras, from Nevada to Arizona, that have been conducted by our parties, we have met a large number of these hardy pioneers hunting for "gold and silver." Those who have wended their way into the remote sections of Colorado, unlike most of the prospectors, however, of the Nevada and Arizona regions, who disdain to labor, except when they are out of "grub," and then are able to replenish the necessities of stomach and pocket in some flourishing mining district, we found many departing from the San Juan mining country, who had been flush in the early part of the chase, but now, instead of one man to four donkeys (a magnificent outfit), four or five men were often seen behind one donkey, the latter carrying all the worldly goods that these men possessed. Cases were presented where charity had occupation, and it was with extreme pleasure that on one we divided four-fifths of what little food we had among a party of men, in order that they might no longer go hungry. It is to be remarked, however, that the total four-fifths of our store was not enough for one meal; still we thought to have added to our record in the cause of suffering humanity.

I would like to call the attention of the Society to the distribution of forest areas, as discovered and entered by parties of the survey. It will be recollected that upon the maps made at the close of the Ives expedition of 1857-'58, there was placed the name of Black or San Francisco forest. Its extent in either direction was not laid

down. However, our surveys go to show that this great forest is probably the largest south of the 40th parallel. It extends from about the 107th to the 114th meridian west from Greenwich, of irregular width, varying from 30 to, say, 100 miles. It is a noble patch of forest, broken only here and there by localities which well might be called parks, not for the reason that the parks in Colorado are so named, but because their variations in landscape have a semblance of cultivation. It is unlike the forests of Northern California, Oregon and Washington territories, where red-wood of dense growth predominates, in being interspersed with little valleys, glades and mountain nooks. There are also areas bordering on the San Juan, and in parts of the territory of Colorado, yet remaining as possessions of the government, so far scarcely touched, and it is to be hoped they may forever remain untouched by the advance of settlement. And here I would remark that it would be well to institute investigations, looking to ascertaining what influence these areas of forest have upon the local amounts of precipitation within their immediate areas.

It is stated in the report of Humphreys and Abbott upon the hydraulics of the Mississippi, that "the removal of forests on mountains will tend to increase the amount of rain, by creating heated upward currents," thus leading to more frequent and violent floods and freshets in the basin of that river. Observations have been made upon phenomena that bear upon this question, and the matured results will appear in the final reports.

It has been frequently noted that in the latter parts of each sunny day, from three to six in the afternoon, a collection of at first fleecy and then cumulous, and afterward nimbus clouds, concentrating toward mountain peaks, occurs, and a precipitation at the crests is noticeable, while at lower levels, say if the mountains are 10,000 to 12,000 feet above the sea, at altitudes between 6,000 and 7,000 feet there is usually no rainfall at all. The connection between the intensity and direction of the electrical currents of the earth's crust, and the hygrometric relations of the atmosphere in such instances, is unquestionably intimate, although at present not fully explained. The facts gathered in relation to water supply above and below the surface are many, and afford satisfactory evidence regarding points at which artesian wells may be successfully sunk, and localities where, by directing the total aqueous precipitation in proper channels of irrigation, arid fields may be made arable. The data gathered in relation thereto will be augmented from year to year by more extended examinations.

NATIONAL ADVANTAGES OF THE SURVEY.

I would endeavor to impress upon your minds the importance of these surveys in regard to their uses to the government. In so doing, I may have undertaken too much, since I am but an humble worker in a small fraction of this great field; yet if one sets forth the plan, wherefrom has grown to the War Department the economy promised in the early stages of this work, one might well be pardoned for venturing upon the yet untrodden fields from which other portions of the government might gather fruit.

To say that the maps of the interior of this country are fraught with numerous errors, is to tell you nothing new. To tell you how these errors may be overcome and rectified were indeed a noble task, but he who accomplishes a remedy, while remaining true to the economical interests of the government, deserves and will receive credit at the hands of all. In the great domain at the West, in advance of settlement and of the acres thrown open to occupation by advancing civilization, the government still possesses lands of which little is known, large parts of which no one representing the government, except now and then a desultory scout, has ever traversed. Into these regions War Department explorations have been sent. Their practical value at the moment may not meet the wants of the settler or the operator, but it is necessary to the government that the place, size and natural and other resources of these tracts should be fully understood, because of present and prospective operations through them, and because of their subsequent entry and sale to parties desiring to avail themselves of the homestead right, etc.

Into these remote, inaccessible and often dangerous regions, parties of the survey under my charge have entered, seeking to evolve practical results from the problems intrusted to them. And what are some of these practical problems? it well may be asked. That from a purely governmental necessity these refer to a delineation of the surface and a description of the resources of the area surveyed, can be easily understood, while from a broad national standard grows the desirability of investigating further into scientific questions, solely bearing upon the distribution of forms in natural history, and in a discussion of the structure of the earth's crust, from stratigraphical and other known relations, and perhaps a practical application of the information gathered to the wants of man.

The great secret of solidity for a work of this nature must grow, however, from the fact that the useful information gained, repays its cost, granting which, upon this as a foundation may from time to time cluster the labors of the scientist engaged in advancing inquiries

in special fields beyond the present domain of knowledge, wresting from nature hidden truths, to formulate them into a "law," nevertheless the mission of the *Engineer* remains the same, and in its simple way should apply all that is great and all that is small of formulated science to the practical objects had in view.

Making maps of the interior, scientifically accurate throughout all their parts, has not as an original proposition been attempted until late years. Our admirable organizations, the United States Coast Survey, United States Lake Survey, and River and Harbor Surveys, answering special purposes, and the expeditions for exploration and survey, and more lately the land surveys have been the principal sources from whence have grown the authentic maps of the country, and little question has ever been raised as to the expenditures made for carrying on these great works, but the utility of furthering extensive schemes of survey founded upon a broader policy, of the great interior, west of the Mississippi, has repeatedly received an apathetic hearing at the hands of Congress. The only method of securing a permanent position for a survey organization, it seems to me, is to place it as a subject to the needs of a department of the government, fulfilling which it will reach phases of economy to interior sectional interests, and with it will grow a policy co-equal with the wants of the government, so settled and lasting as to bring to the support of enterprises under it in course of time many of the best educated minds of the country, whether military or civil. While writing my last annual report, some of the uses and needs of these explorations and surveys to the War Department came into my mind and were recorded as follows:

1st. The published maps, profiles, and compiled distances over present and future routes of communication and supply that look to a saving in cost of transportation of all materials and munitions of war and other supplies forwarded through the Quarter-master's Department of the army. As a correct understanding of the topographical features of a country is necessary to all military operations, either in times of war or peace, the necessity for the acquisition of this information in a systematic form at the War Department, and its dissemination through the different branches of the military service, becomes apparent.

2d. The establishment of routes of communication necessary for the supply of interior posts. For an understanding of the above, the inter-lying country requires thorough examination.

3d. Critical routes to be followed in the interchange of troops between distant stations when demanded.

4th. New and shorter routes for forwarding recruits to their companies and stations.

5th. Routes for scouts pursuing hostile or unfriendly Indians.

6th. The selections of sites for new military posts established in advance of, or as safeguards to, civilization.

7th. Routes for troops when called out for the protection of miners or settlers.

8th. A knowledge of the resources of the country surrounding the military establishments, and its capacity for furnishing supplies.

9th. Routes of transit when troops are ordered to remote points in aid of the civil law.

10th. A knowledge of the character and habits of the several Indian tribes, and their disposition toward each other and toward settlers.

The above are a few of the classes of examinations necessary and valuable to the several Bureaus of the War Department and to the commanders of troops in their pioneering into the unoccupied and comparatively inaccessible portions of the western interior.

To obtain such information that should be at all times immediately available for the uses of the War Department, such observations as are necessary for an *accurate delineation and description of the surface and resources of the area surveyed* must be made. This calls for geographical surveys in their highest and broadest sense.

The advantages to industrial interests growing from the examinations made by a body of skilled men, mobile enough to be dispatched with little warning to any region west of the 100th meridian, no matter how remote, and sufficiently stable to successfully accomplish required objects, is not likely to be overestimated. That the Department, supervising their duties, requires immediate results is a guarantee to an activity that is advanced by a species of discipline, without which certain if not all features of an expedition might fail. The necessities of the army as protectors of and as a nucleus to advancing population in the west has so deeply rooted itself in the popular mind of those sections as to render it unnecessary to dwell upon the benefits coming from the continuous exploration which forms no little part of its duty. It is believed that the standard of geographical work established in the past few years will, if energetically continued, add an increasing amount of enthusiasm to emigration and to the legitimate establishment of the great industries, from the systematic information rapidly acquired and made as speedily as possible accessible to the public. When we may reach a policy that surrounds with an entity of relations, the standard accepted for the work, then the

economic problems of the routes traversed, and the areas occupied may one by one be anticipated and practical results evolved. Until finally from the application of the highest principles of Geodesy to the gathering of the simplest detailed facts, the surveys of our interior will be constantly advanced until there shall be reared to Geography a proud monument at whose base shall lie the mighty domain that is our inheritance as a government, the States and Territories of the United States of America